

Self-assembly of Nanoparticles in Sensing Platforms

**S. Mitra, C. Saridara, M. Karwa, R. Brukh,
and Z. Iqbal**

**Department of Chemistry and Environmental
Science**

**New Jersey Institute of Technology, Newark,
NJ, USA.**



Outline

- **Introductory Concepts**

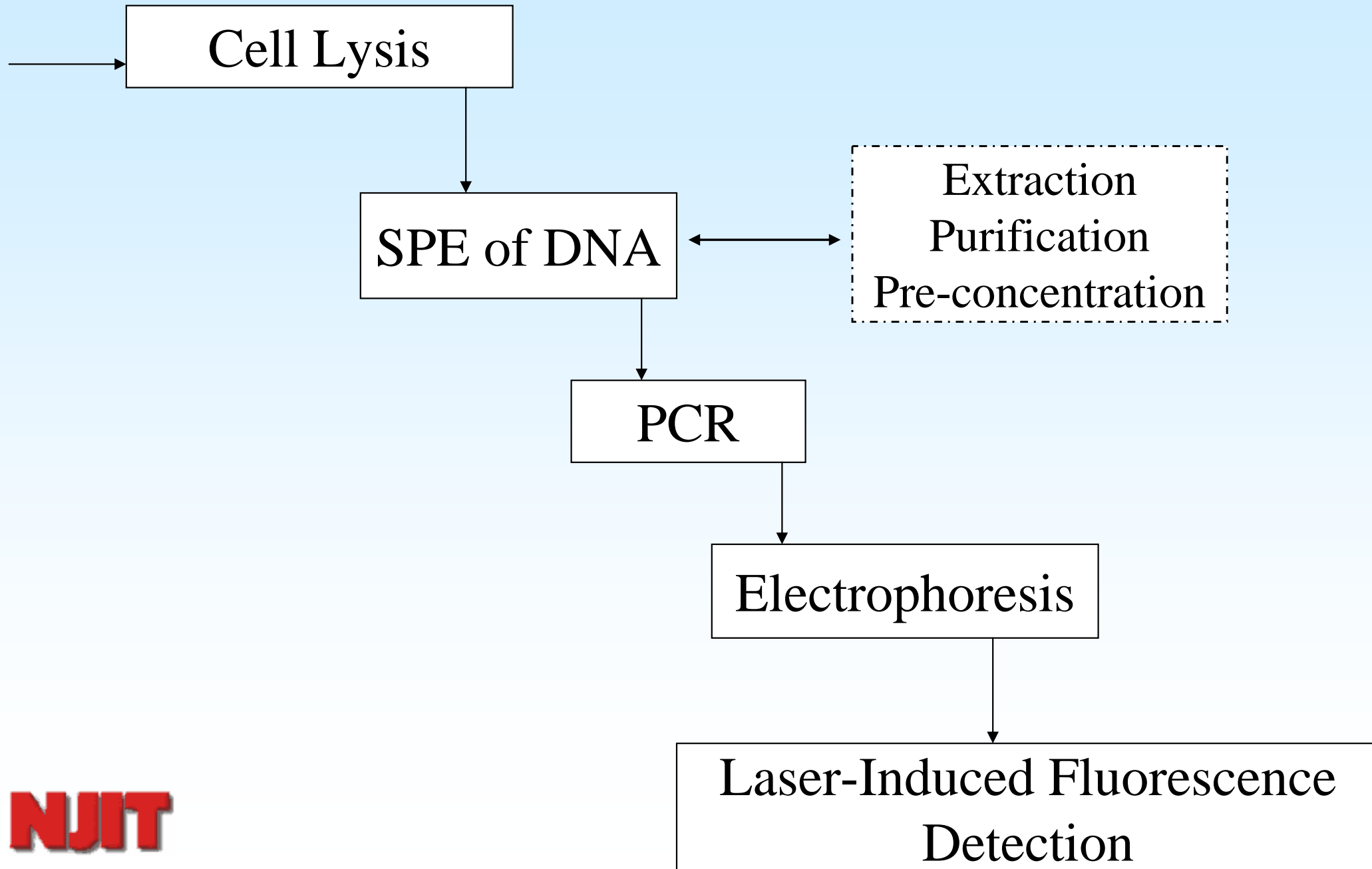
- Lab on a chip for DNA sequencing
- Approach to trace air monitoring
- Micro-trap modulated detection
- Carbon Nanotubes: Concepts, synthesis and images

- **Results**

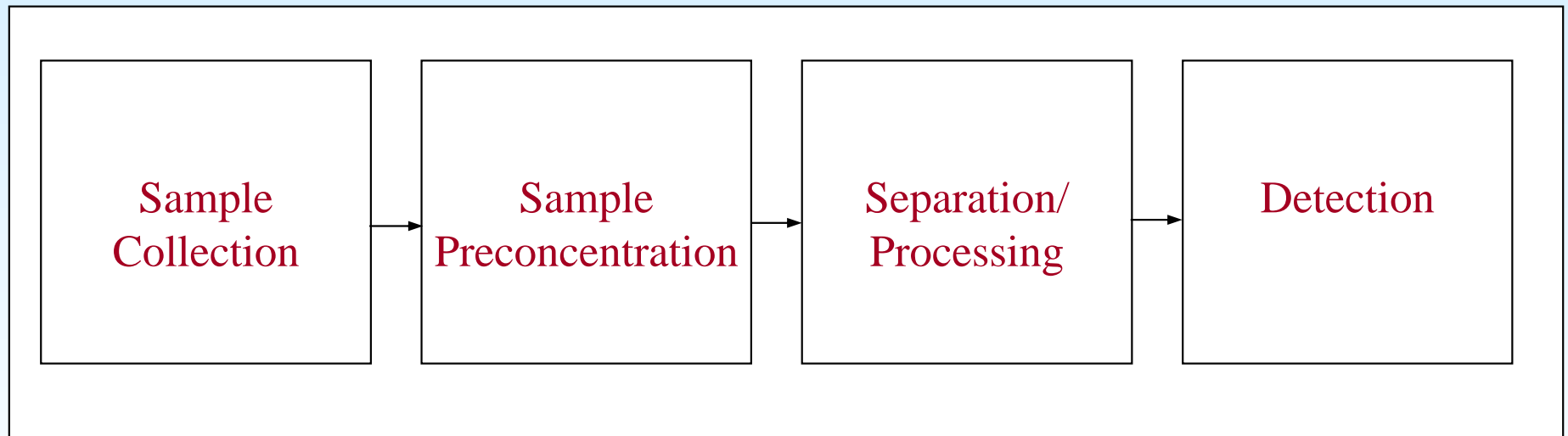
- Carbon nanotube micro-traps
- Silica nanoparticle SPEs

- **Summary and Final Thoughts**

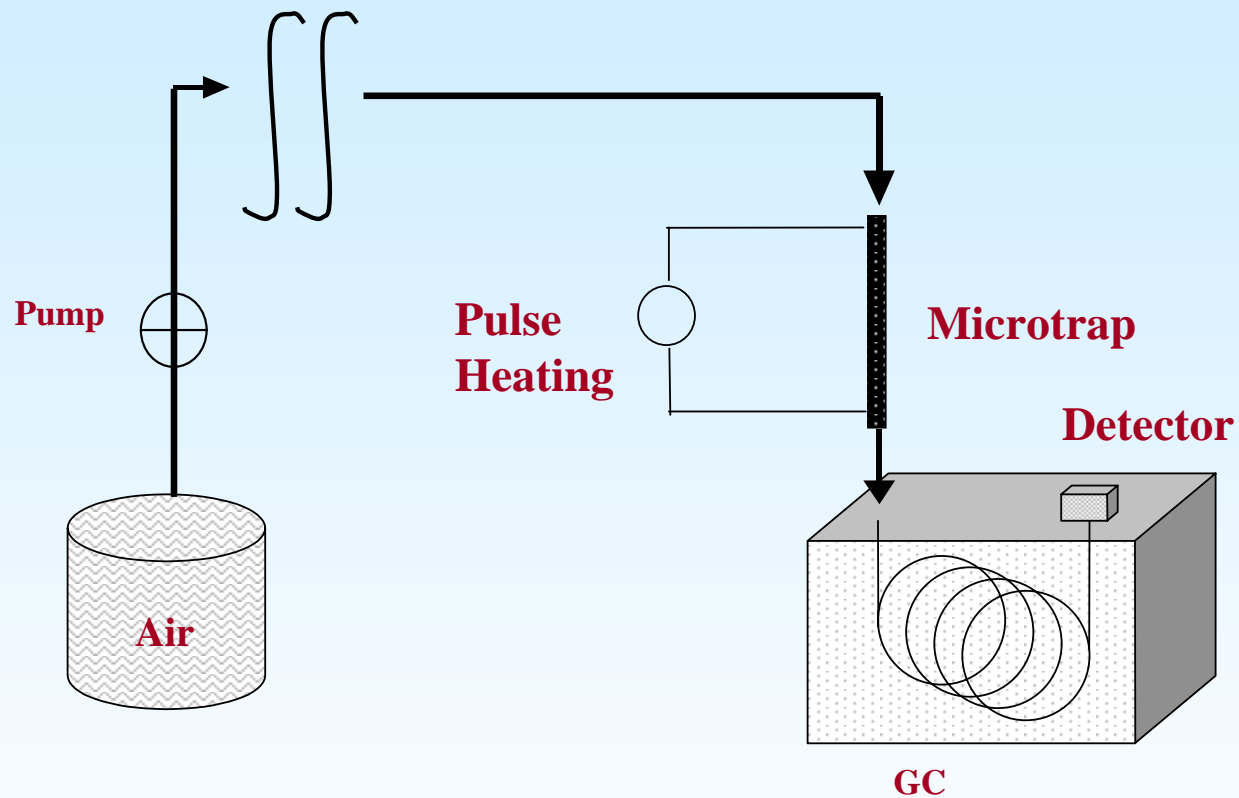
Lab-on-a-chip for DNA Sequencing



Approach to Trace Air Monitoring



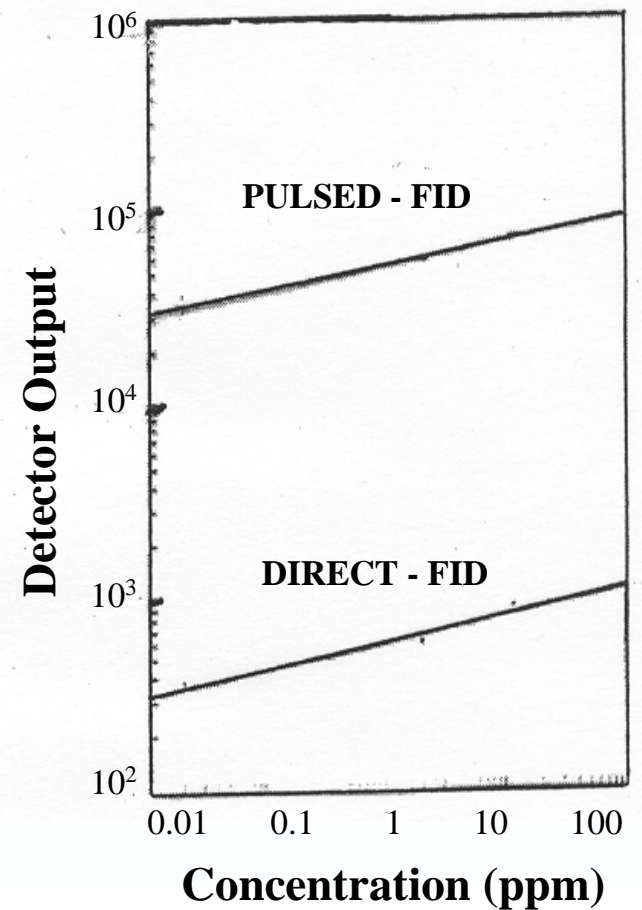
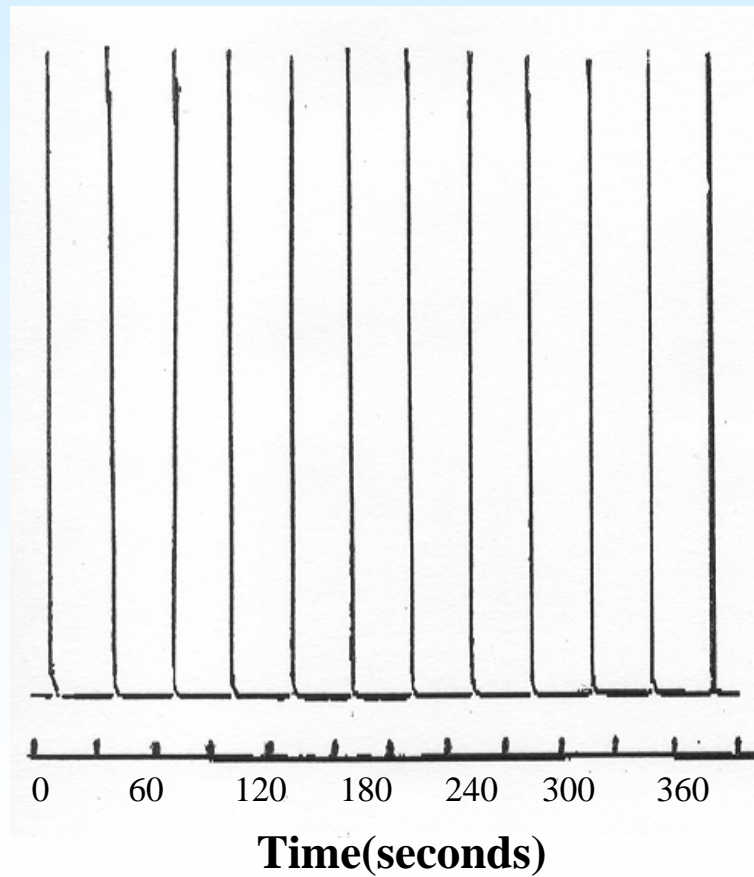
Microtrap Modulated Detection

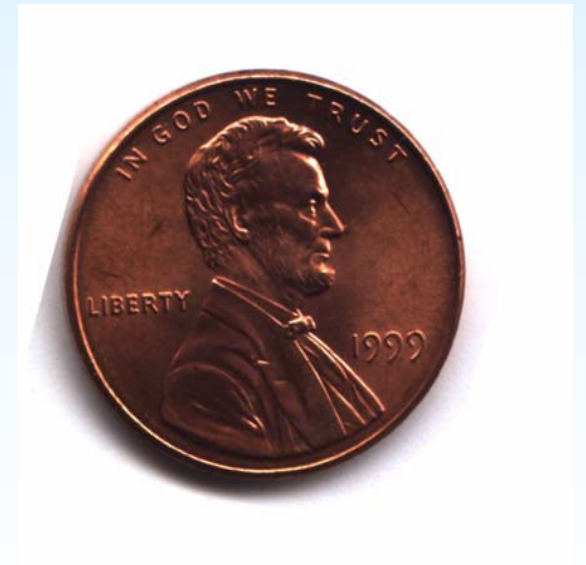
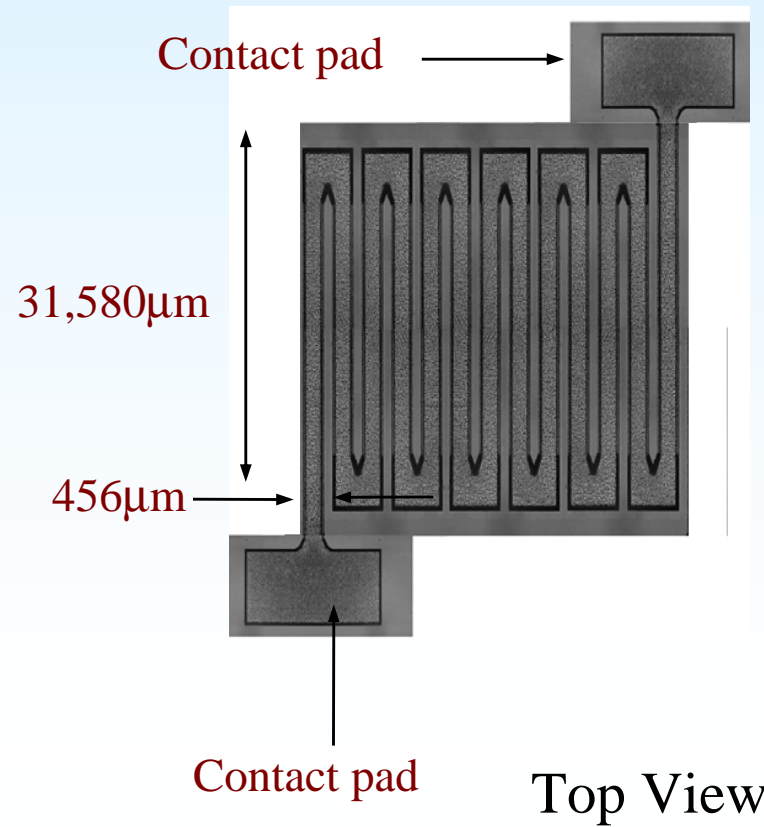
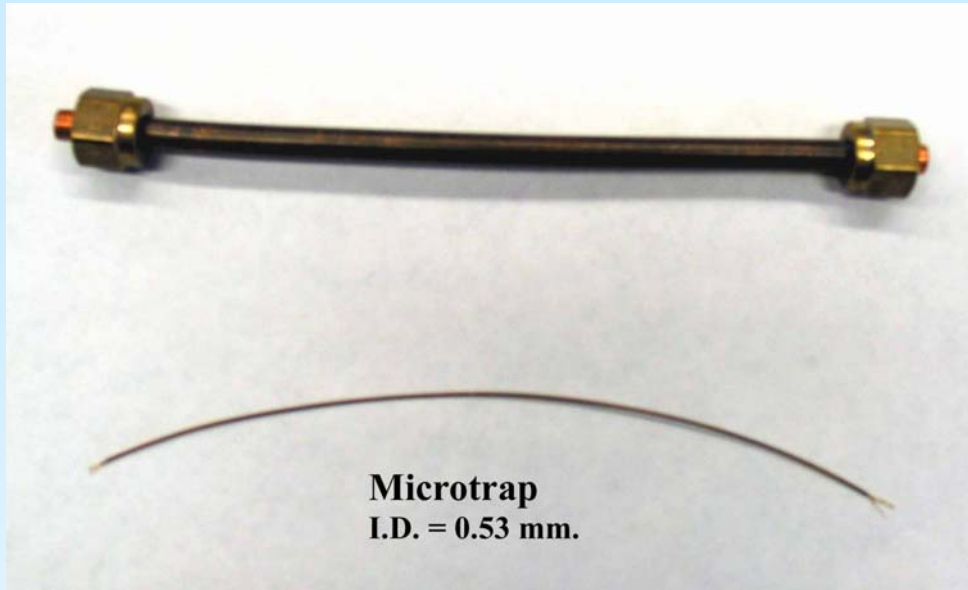


M. Kim and S. Mitra, *J. of Chromatogr. A.* 996, 1-11 (2003).

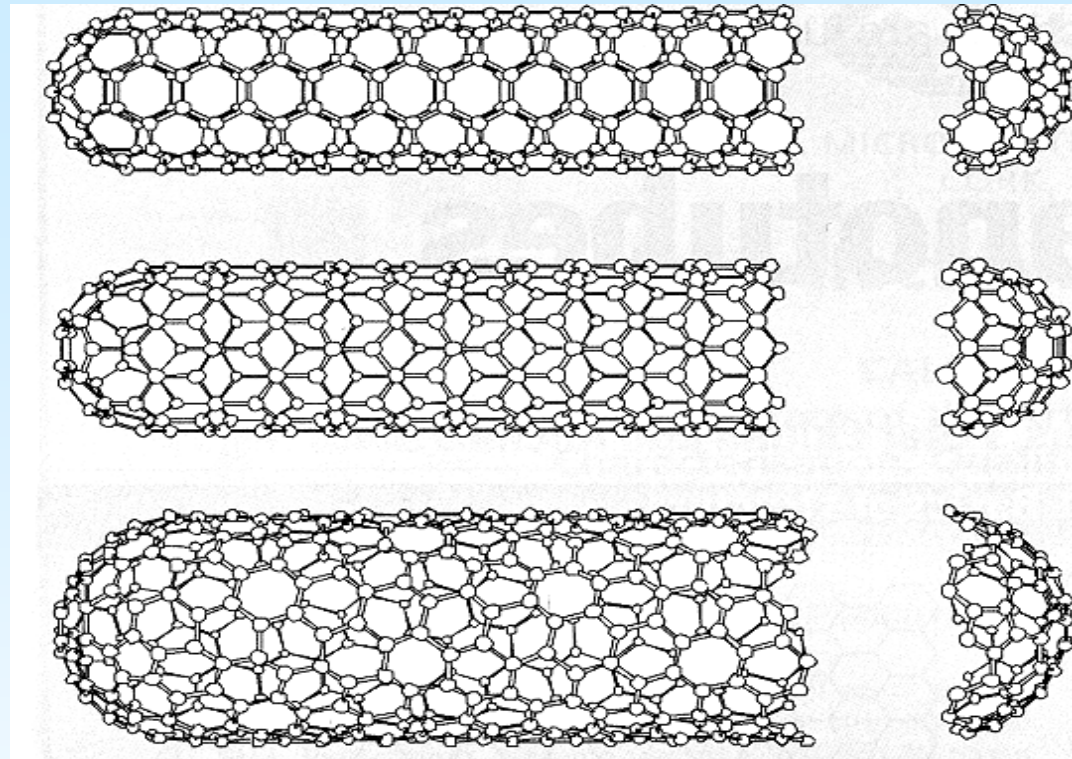
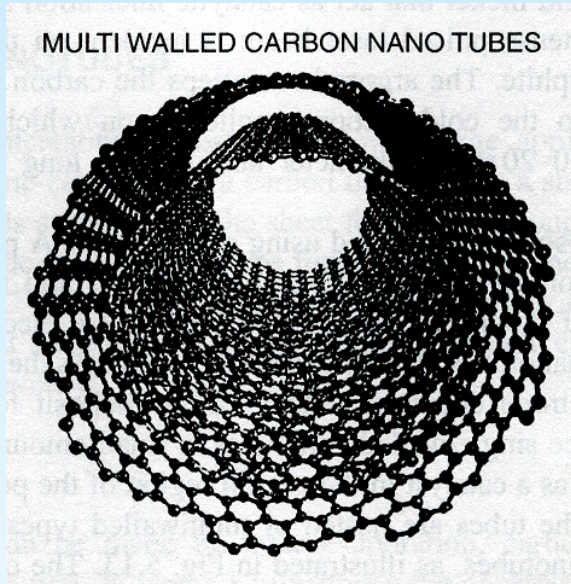
C. Feng and S. Mitra, *J. of Micro. Col. Sep.* 12(4) 267-275 (2000).

Response of Microtrap Pulsed Detection





Single wall carbon nanotubes (SWNTs)



Arm-chair

Zig-Zag

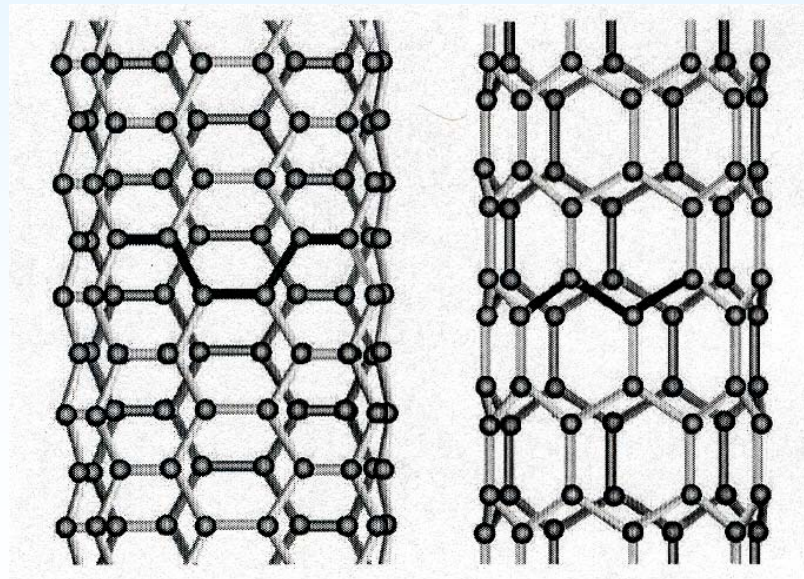
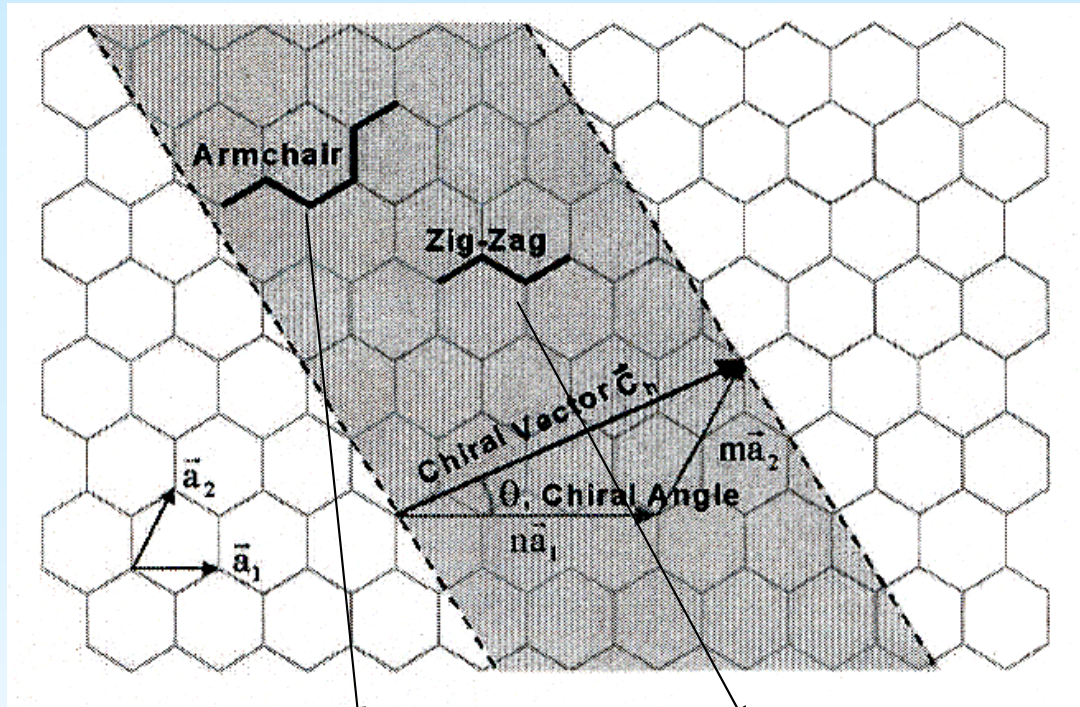
Chiral

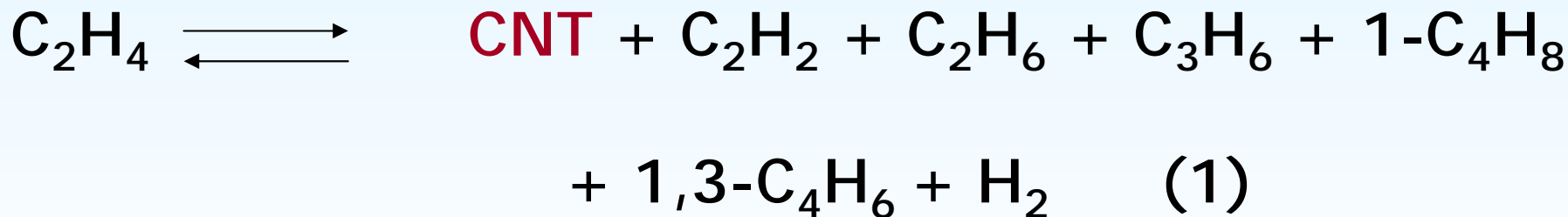
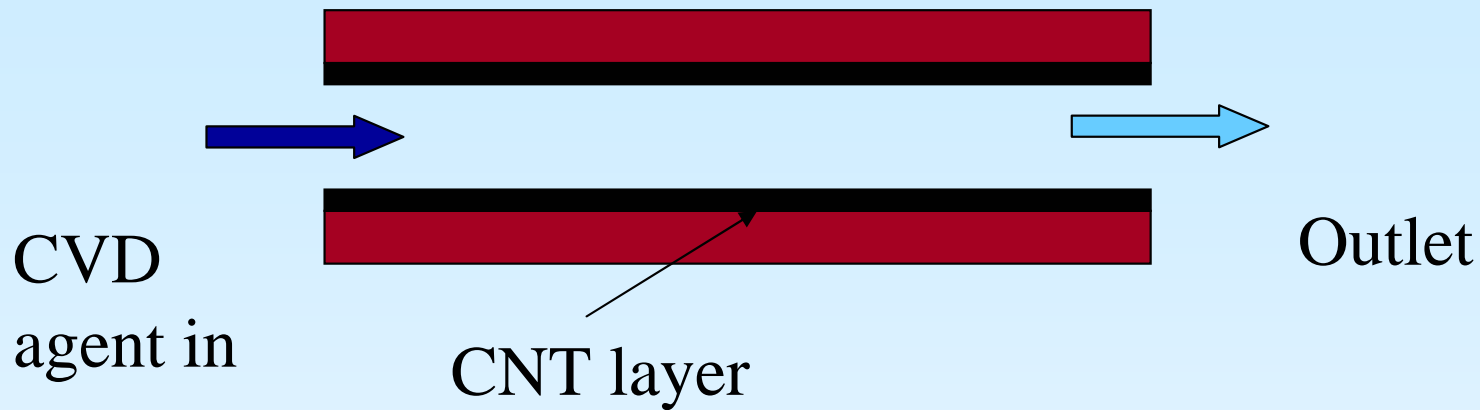
Individual SWNTs usually assemble as 0.5 to 20 nm bundles

Synthetic Routes:

- Laser Ablation
- Arc Discharge
- Catalytic CVD

Construction of a Nanotube

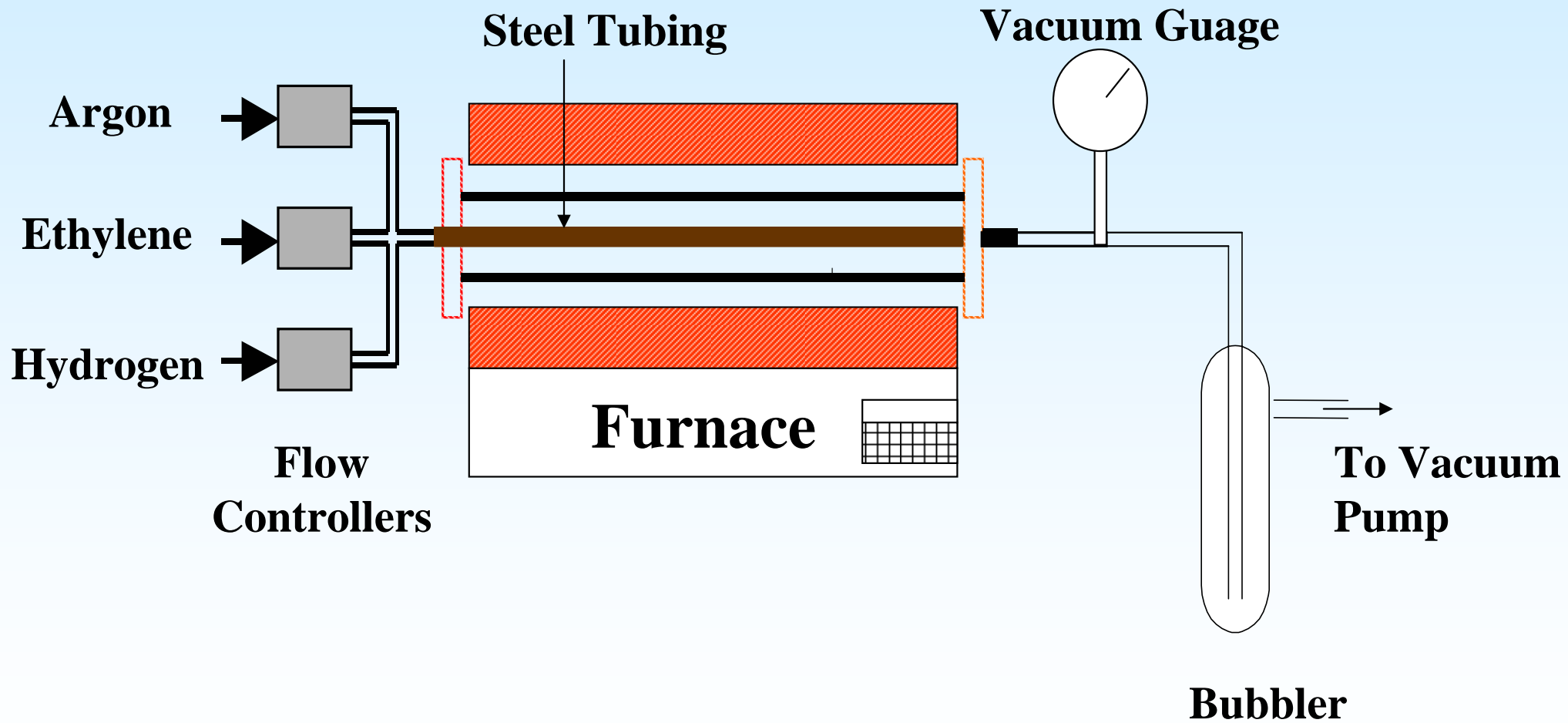




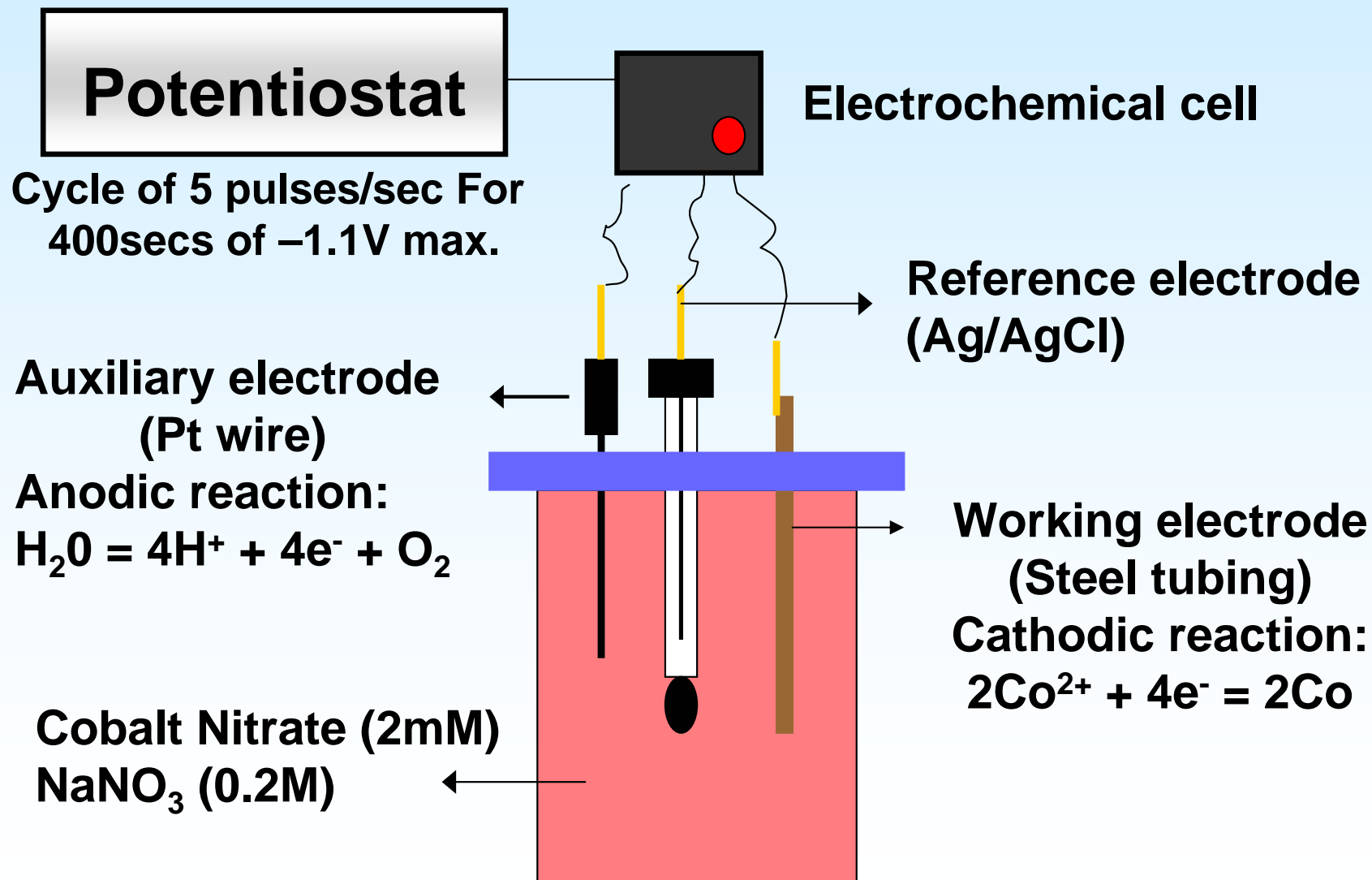
(1) Ref. : Can. J. Chem./Rev. Can. Chim. 78(1): 16-25 (2000)

(2) Ref. : Jacobson, B.I, Smalley, R.E, Am. Sci., 85, 324 (1997)

Self Assembly of Nanotubes in Microtrap by CVD

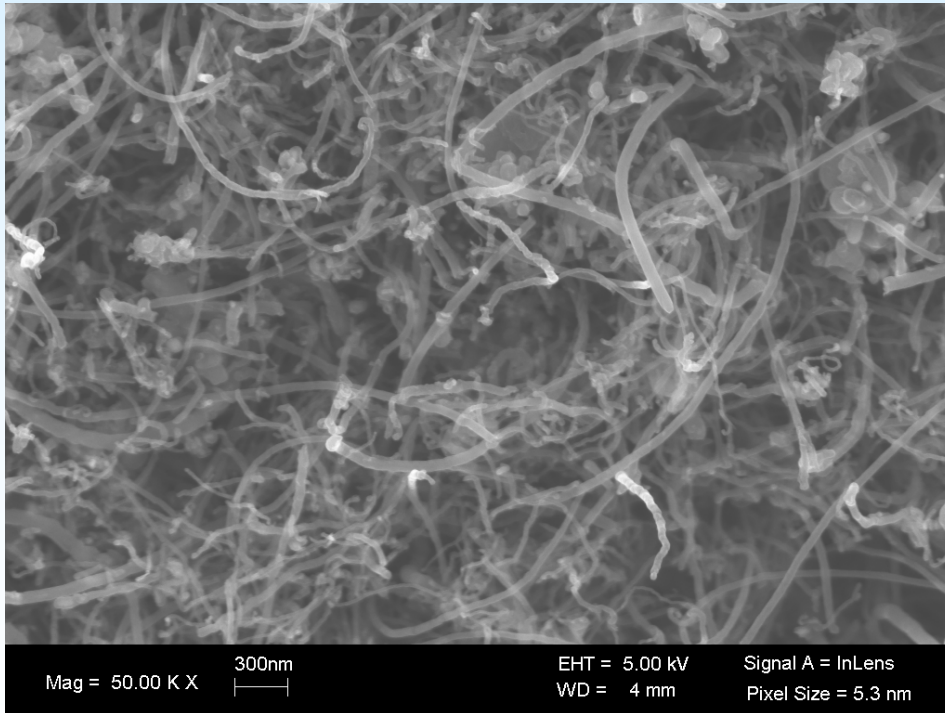


Catalyst Electrodeposition

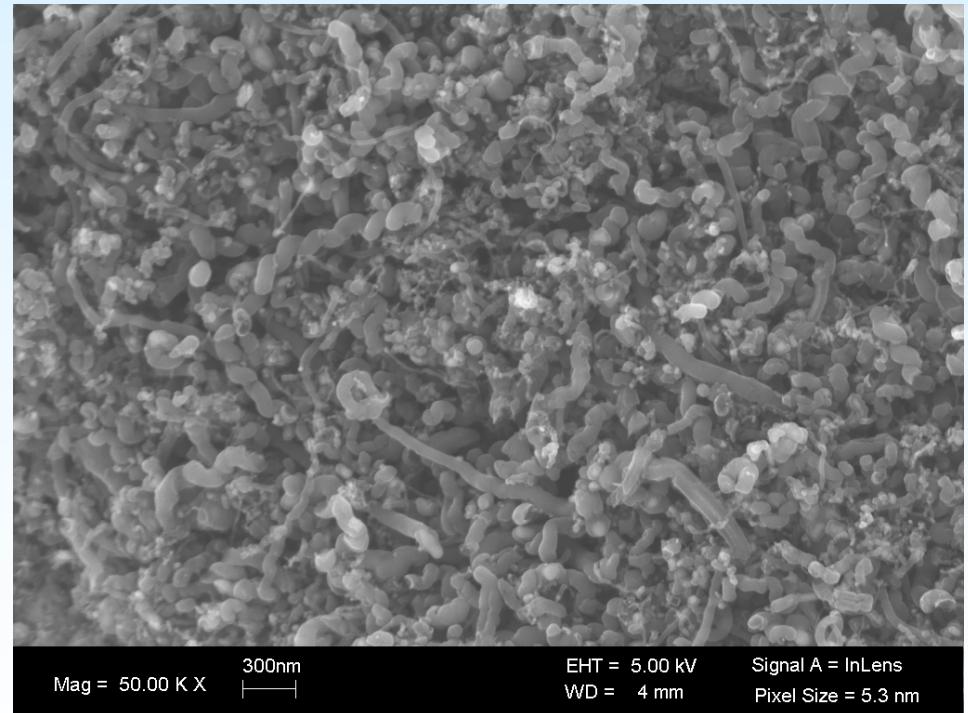


CVD Assembly of CNT in Microtrap

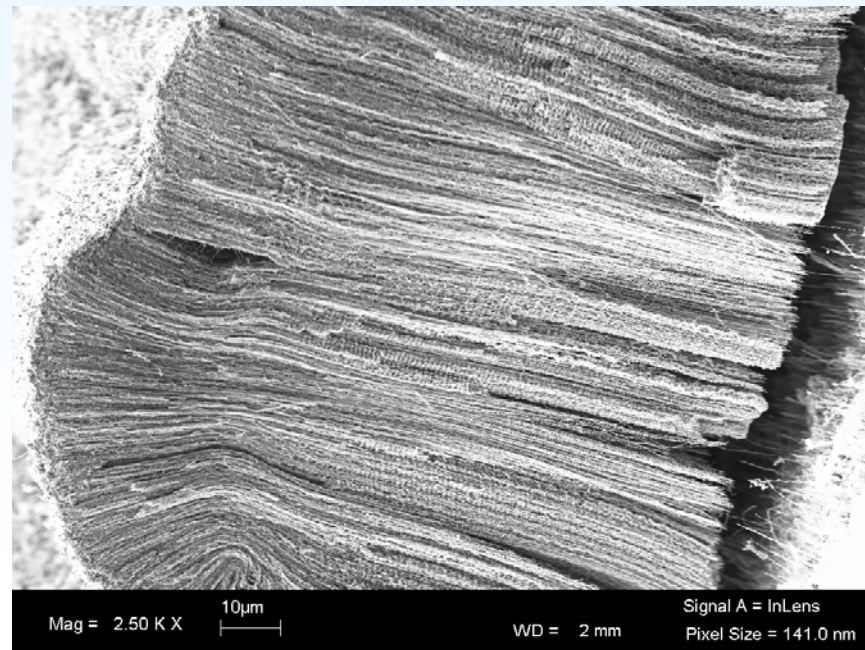
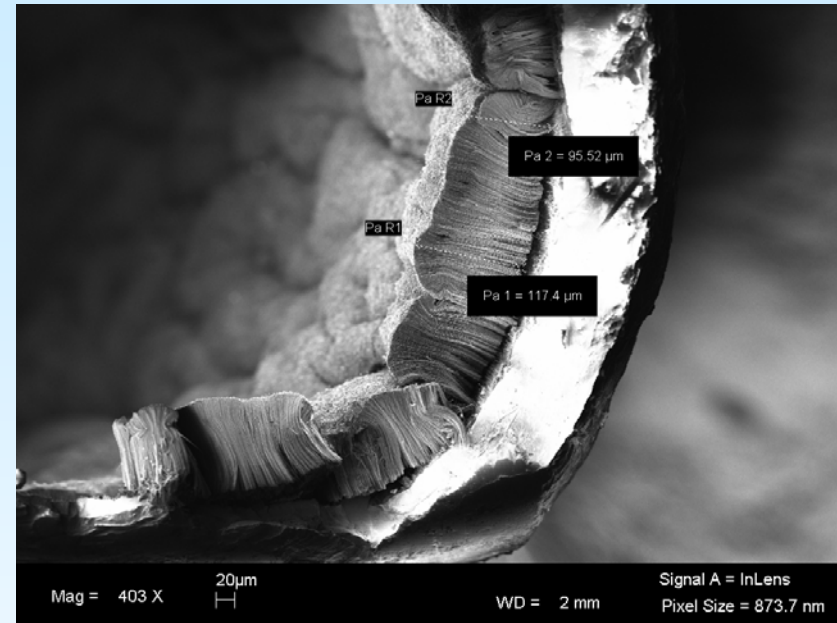
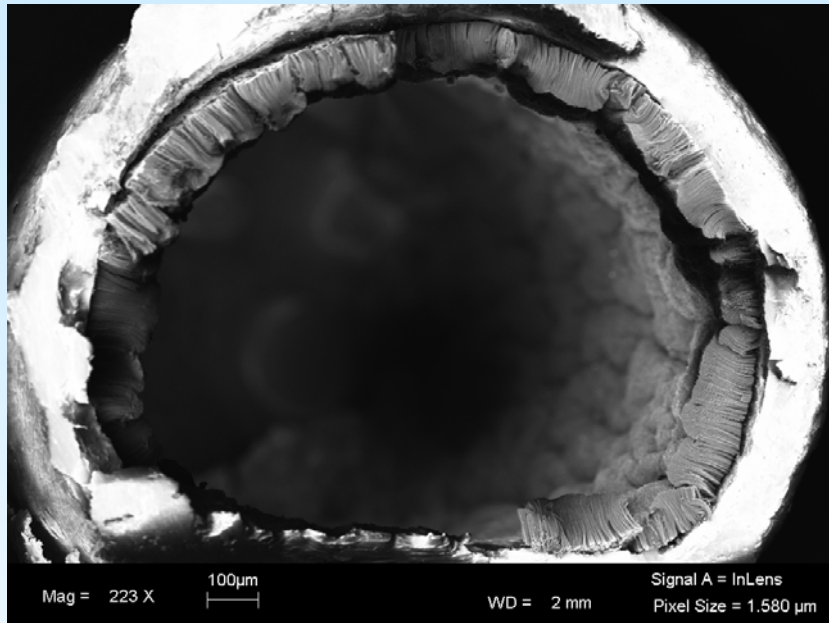
C_2H_4



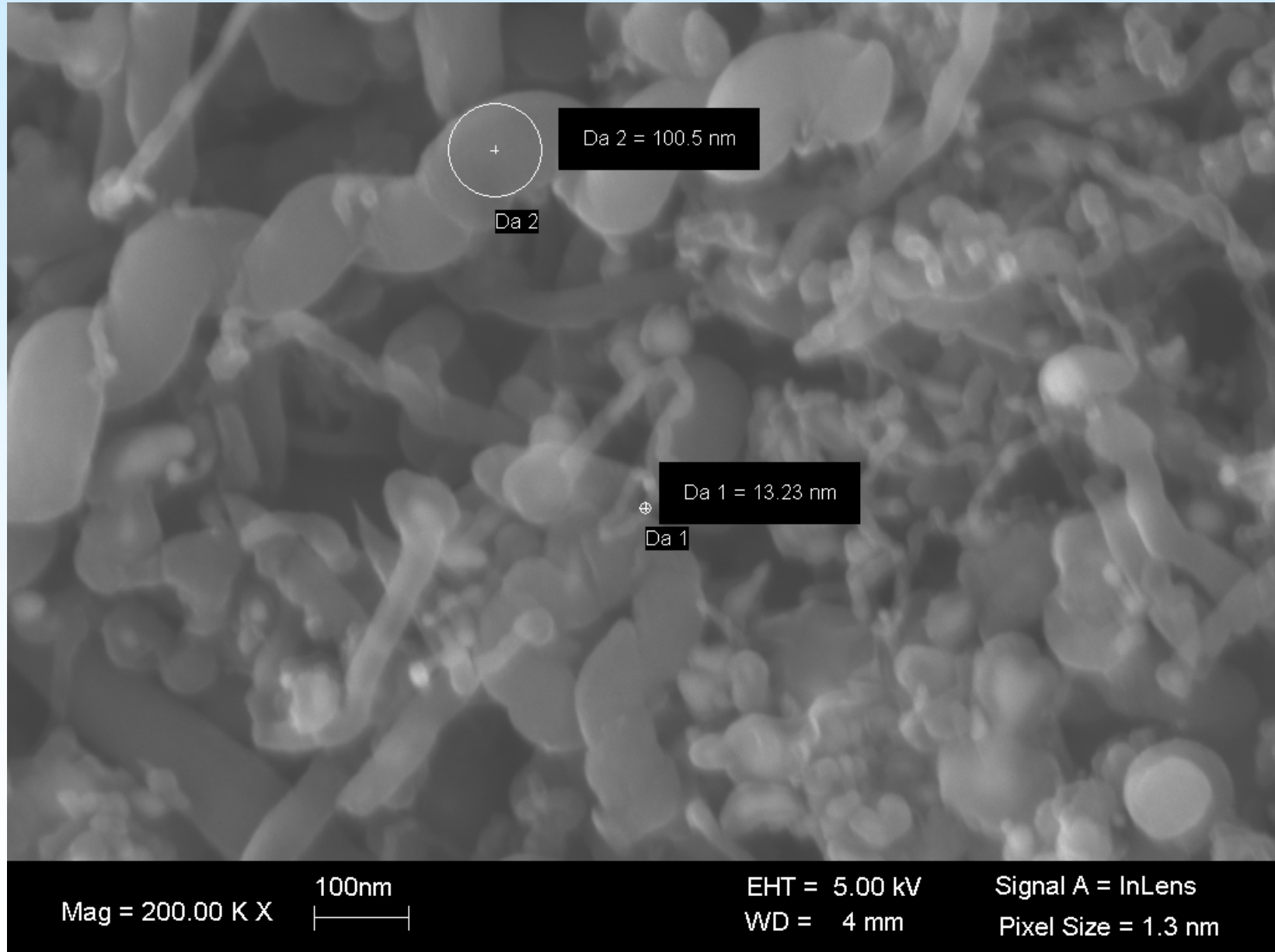
CO



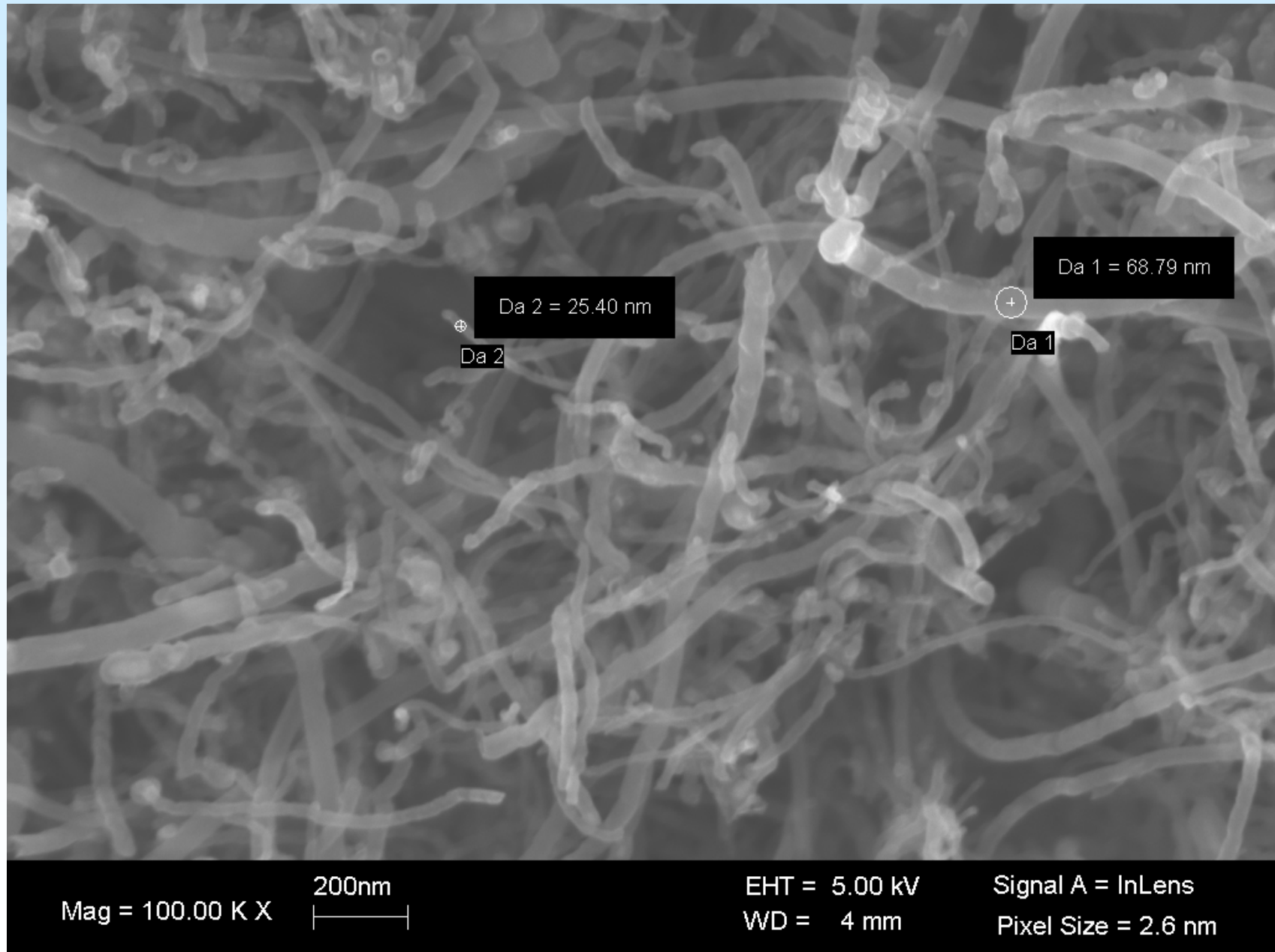
Oriented CNT Assembly by Ethylene CVD in a Microtrap

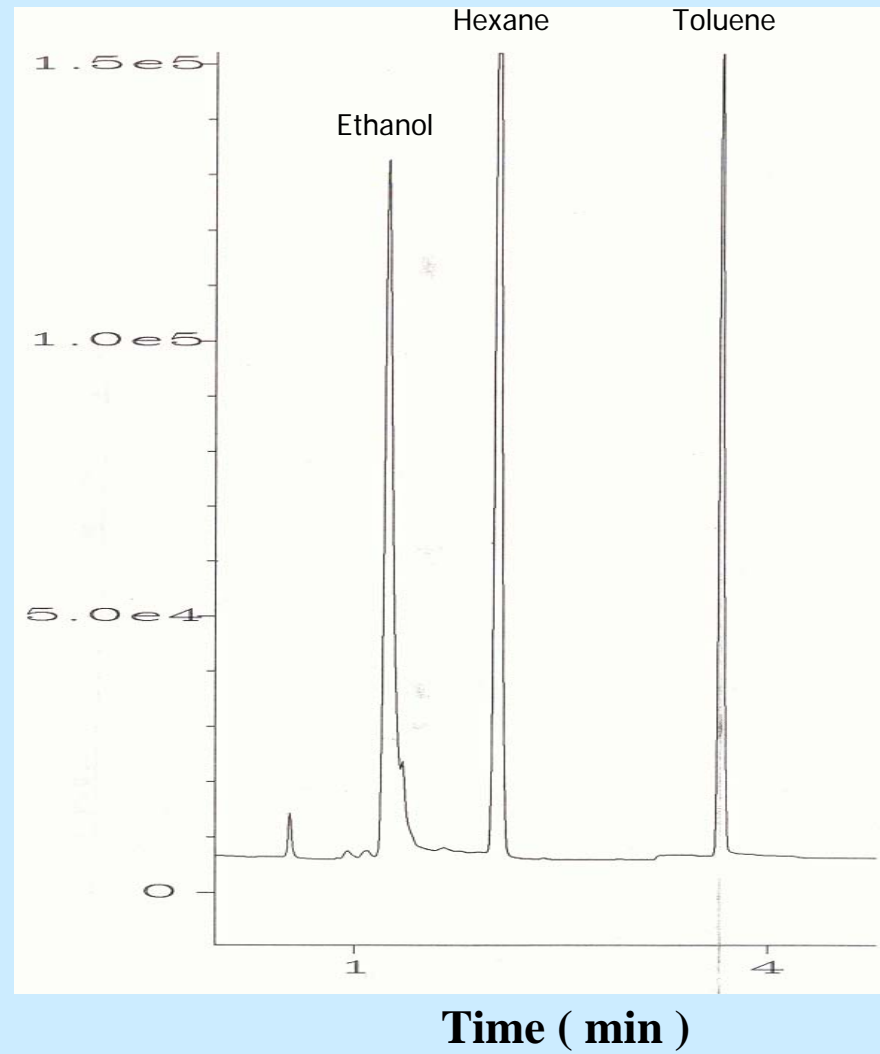
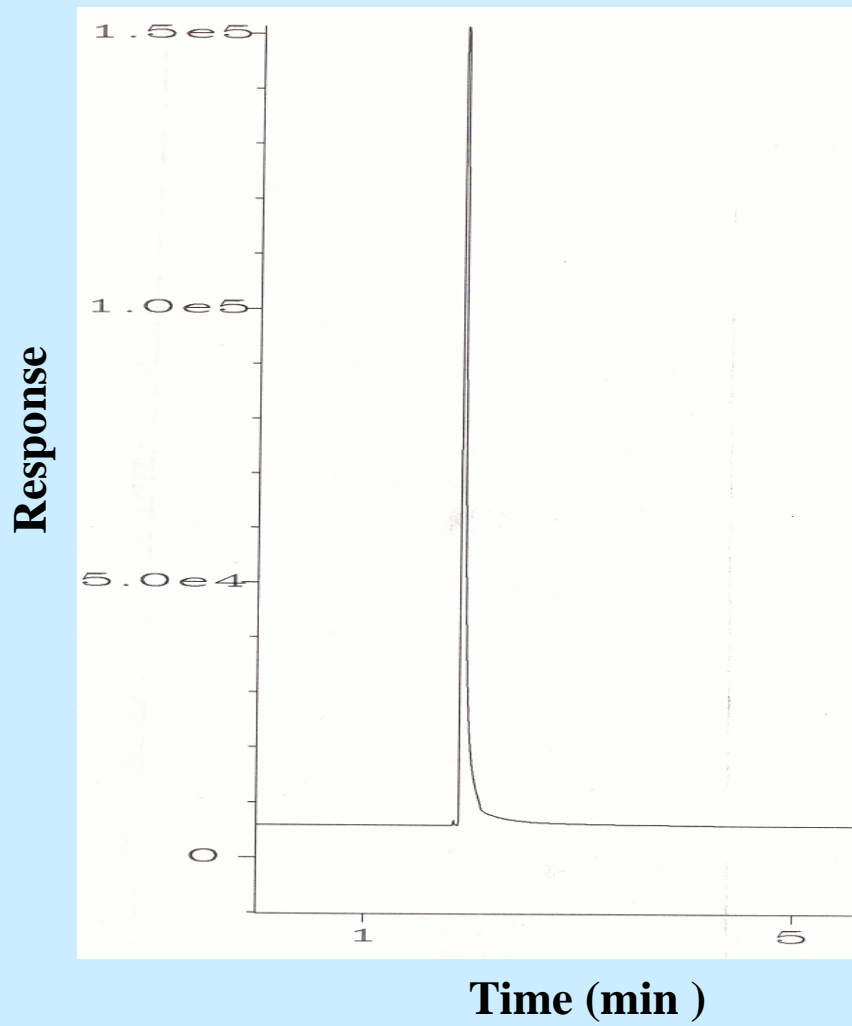


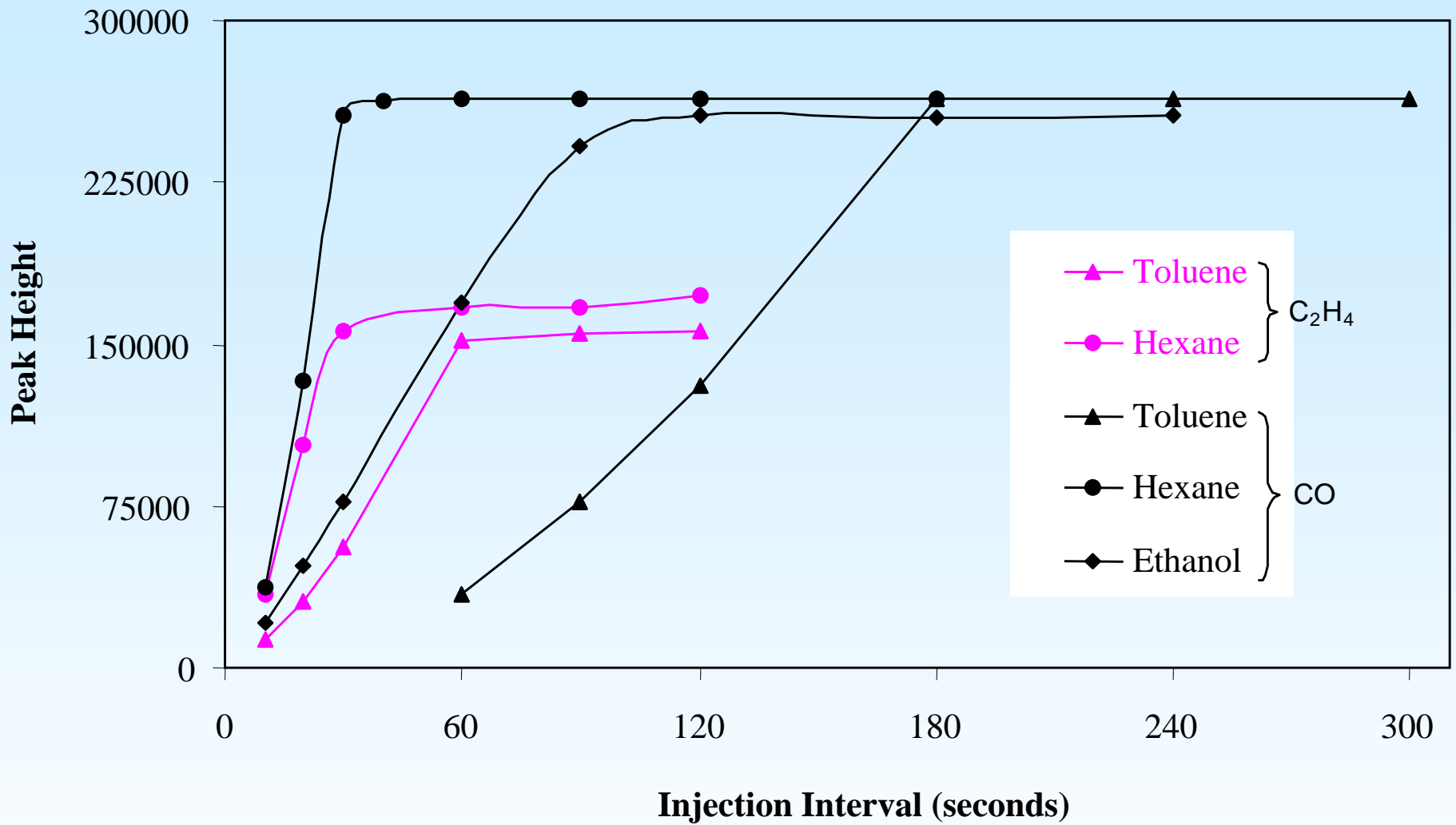
Microtrap by CO-CVD



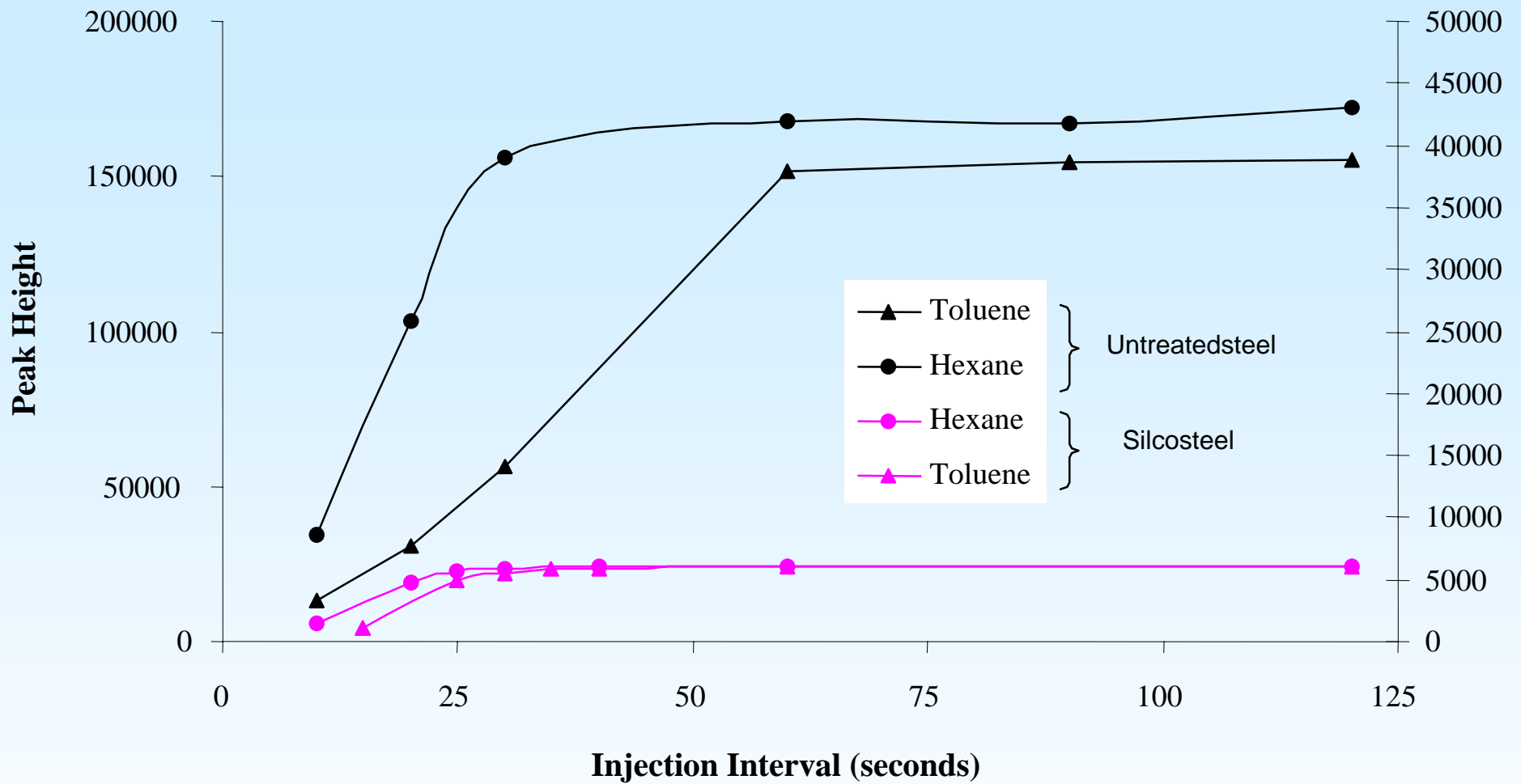
Microtrap by Ethylene CVD







Breakthrough on MWNT- Microtraps made using Ethylene and CO-CVD (untreated steel, 5 hours)

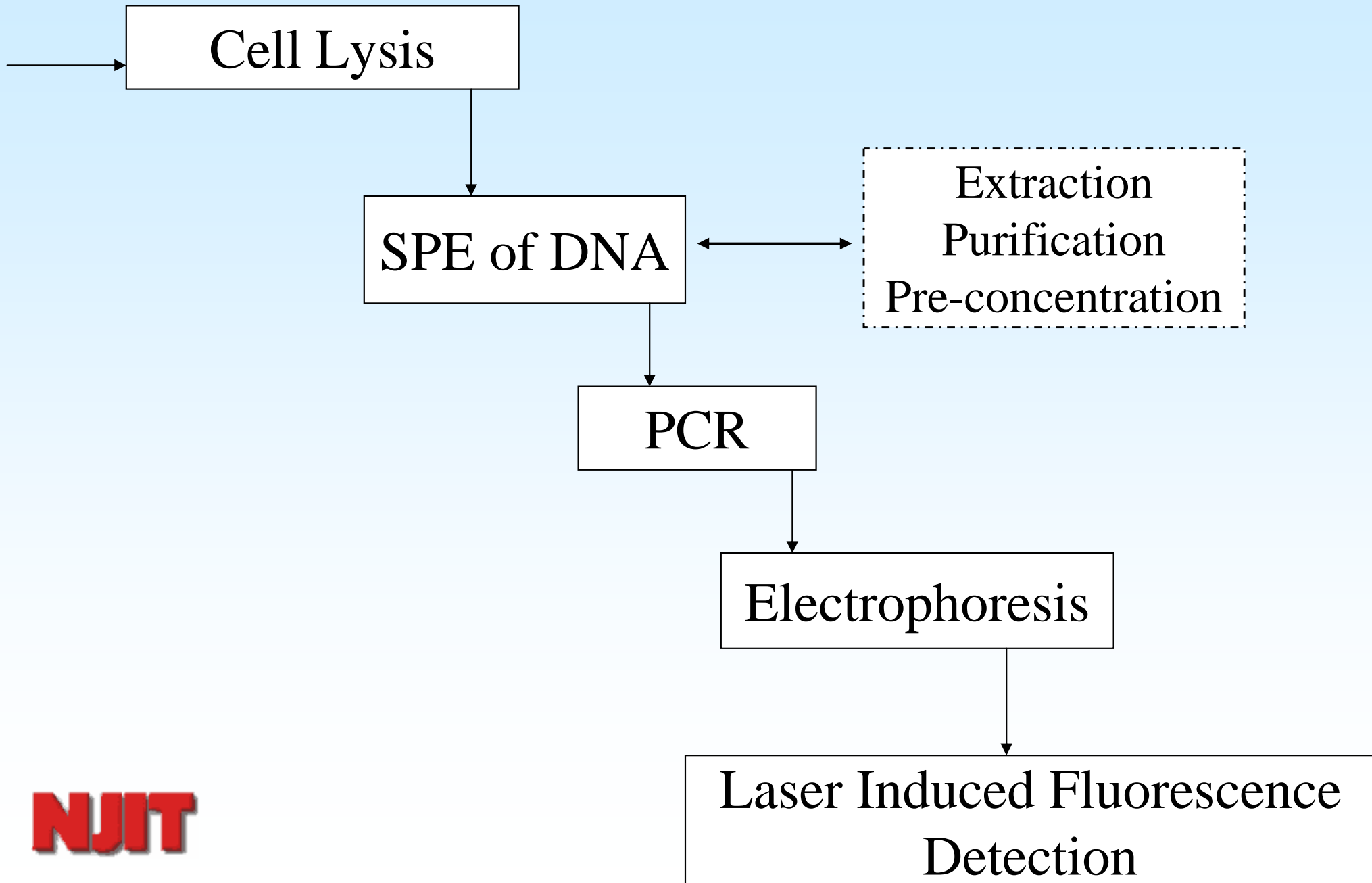


Breakthrough on Silico-steel vs. Untreated steel: MWNT Assembled from C_2H_4 -CVD for 5 hours.

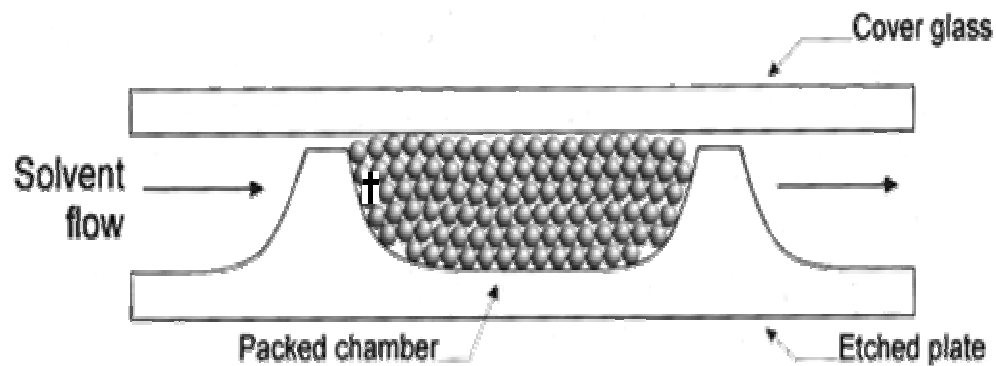
Factors Affecting Trapping Characteristics

- **Compounds used in CVD**
- **CVD conditions – temperature, pressure, time**
- **Surface and Catalyst Preparation**

Lab-on-a-chip for DNA Sequencing

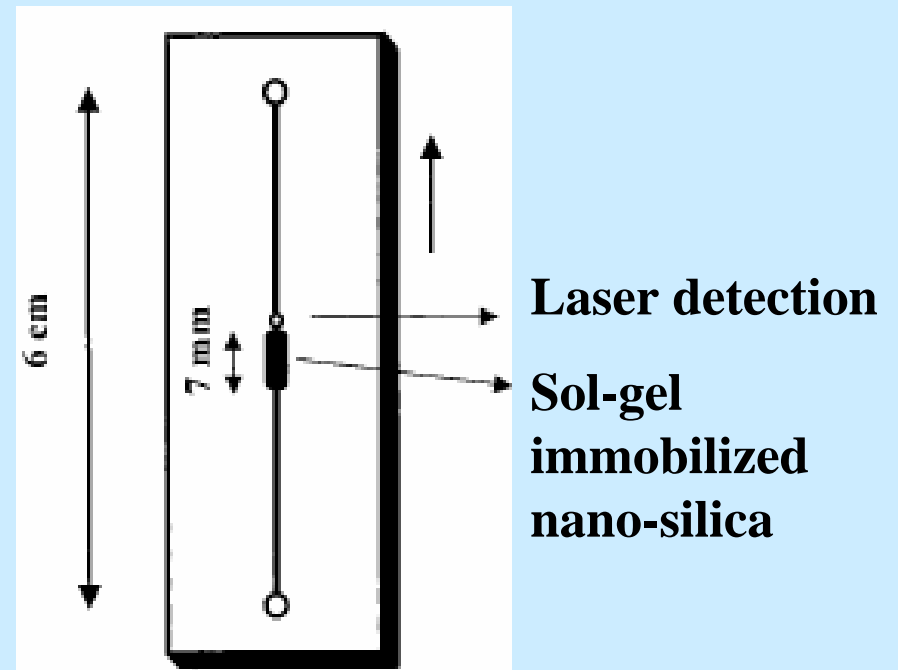


Microfabricated SPE on PDMS Microchannels

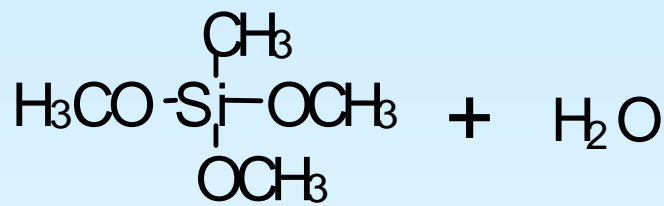


D. Jed Harrison's Group; U. Alberta, Canada

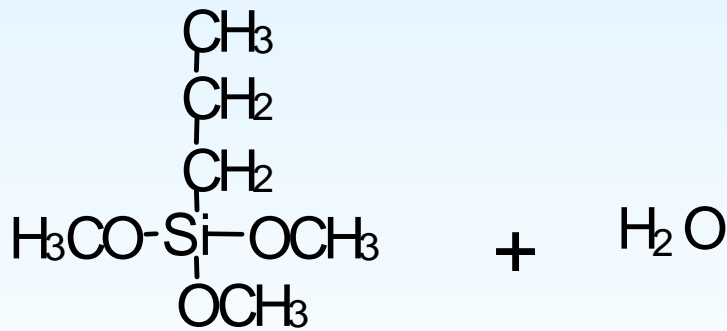
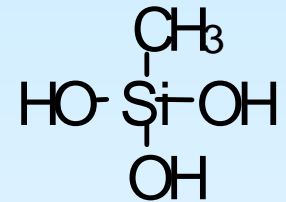
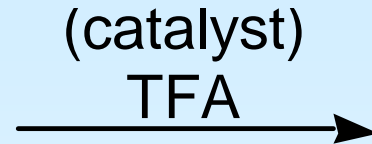
- ODS beads were trapped in glass substrates.
- Electrophoretic flow



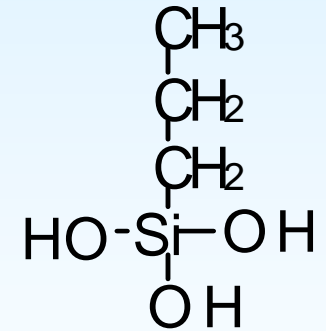
Sol-Gel Chemistry



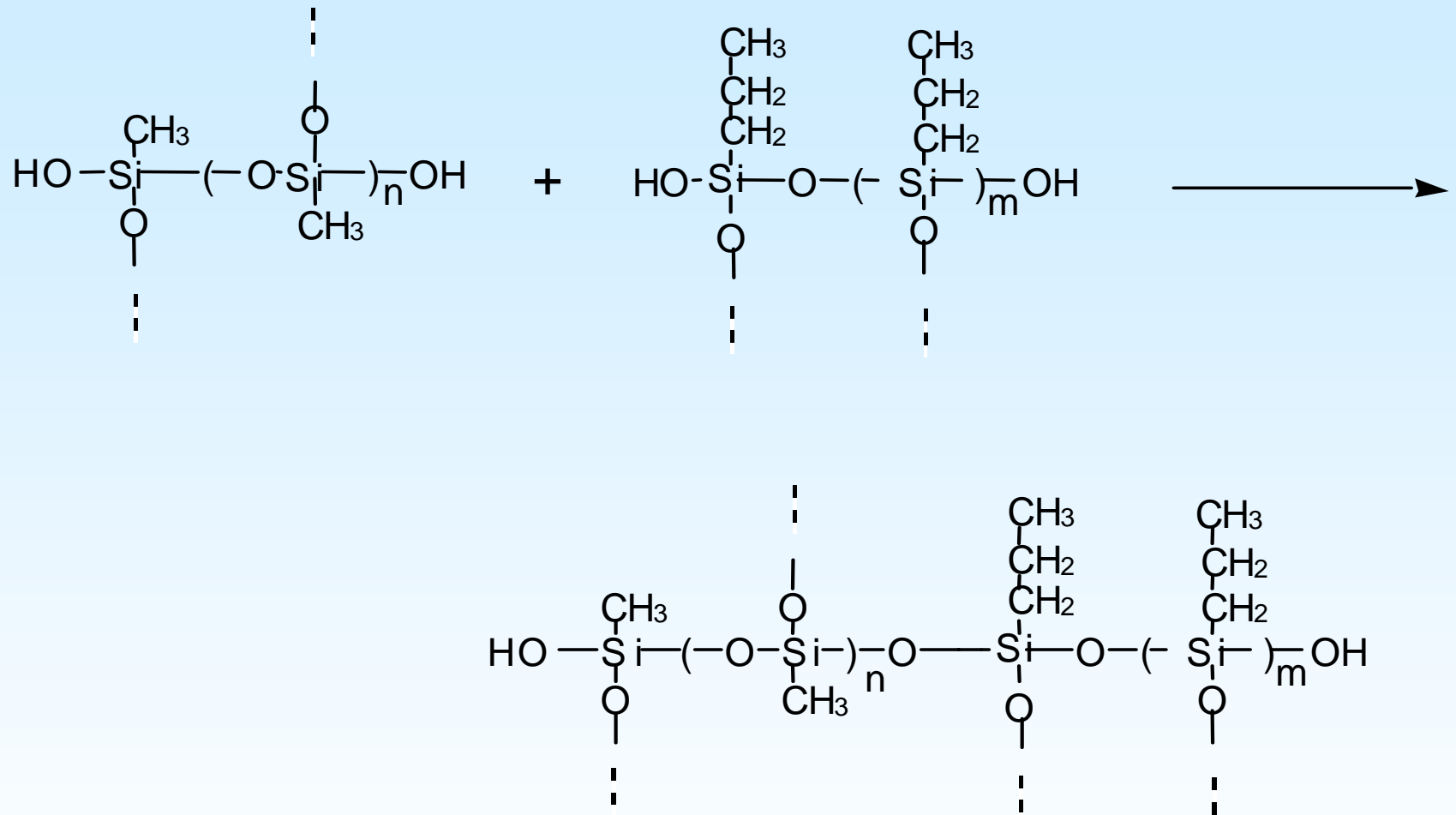
TMMS



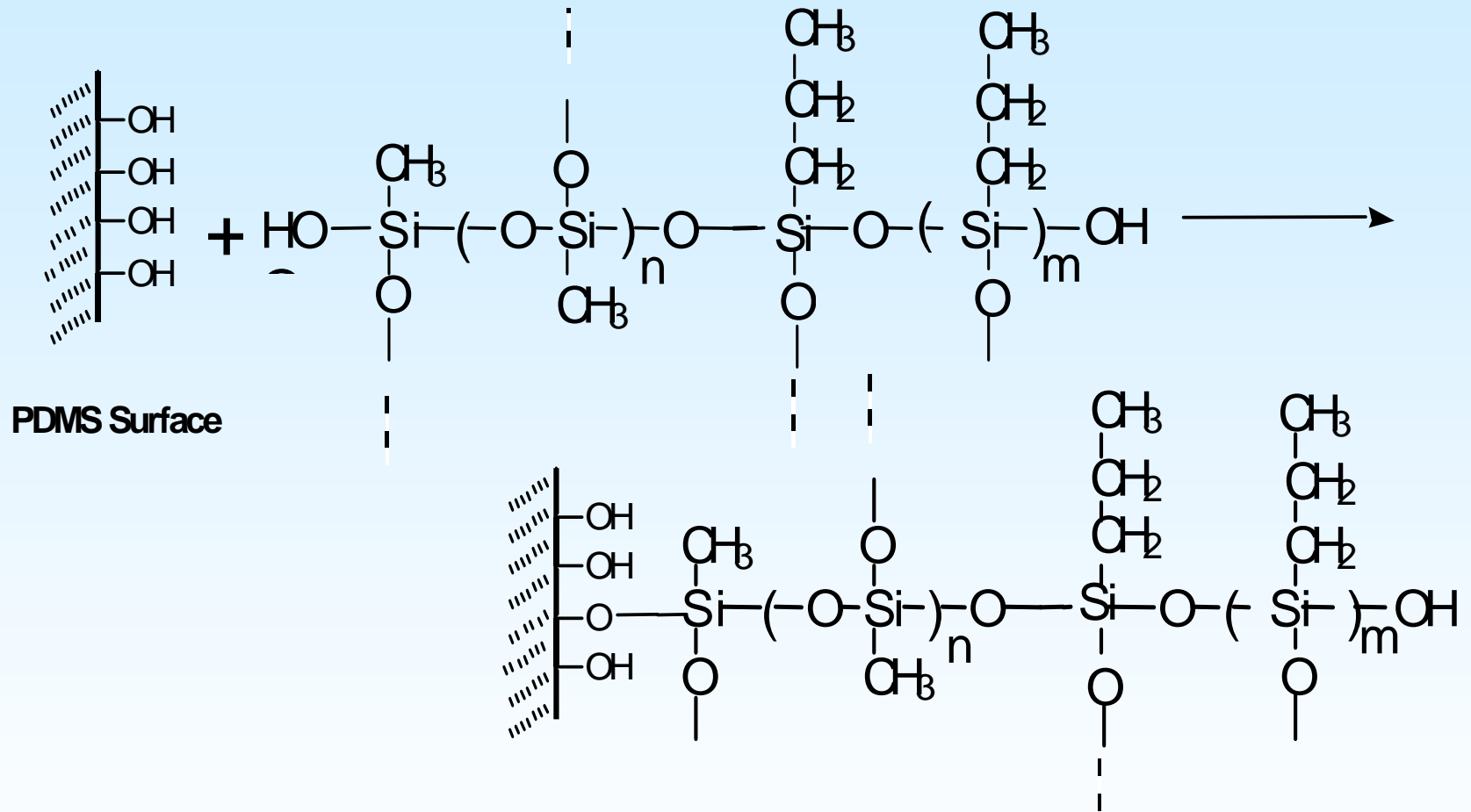
TMPS



Hydrolysis of the sol-gel precursors trimethoxymethylsilane and trimethoxypropylsilane

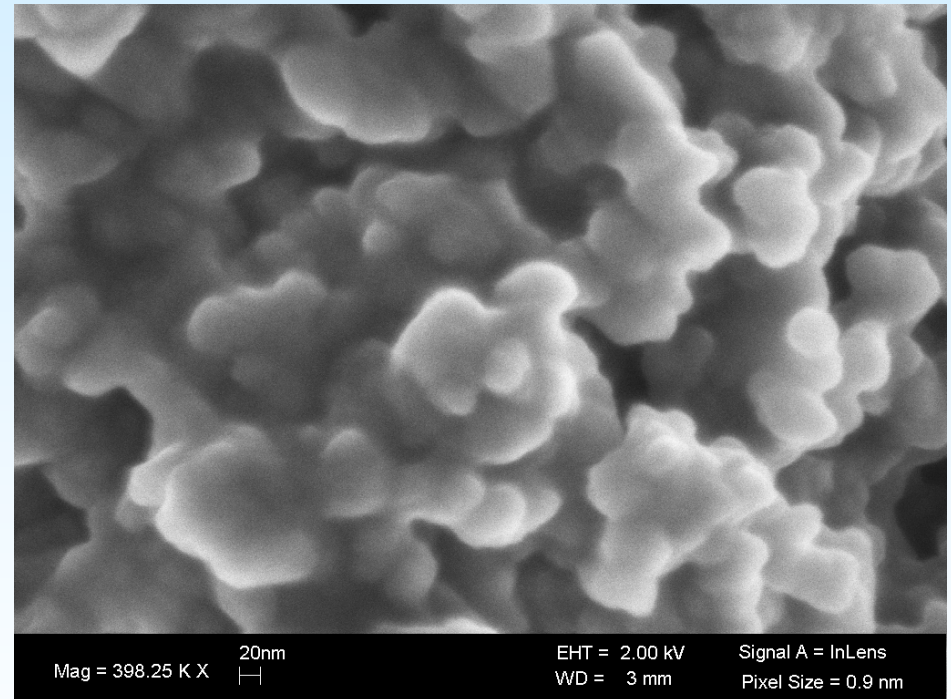
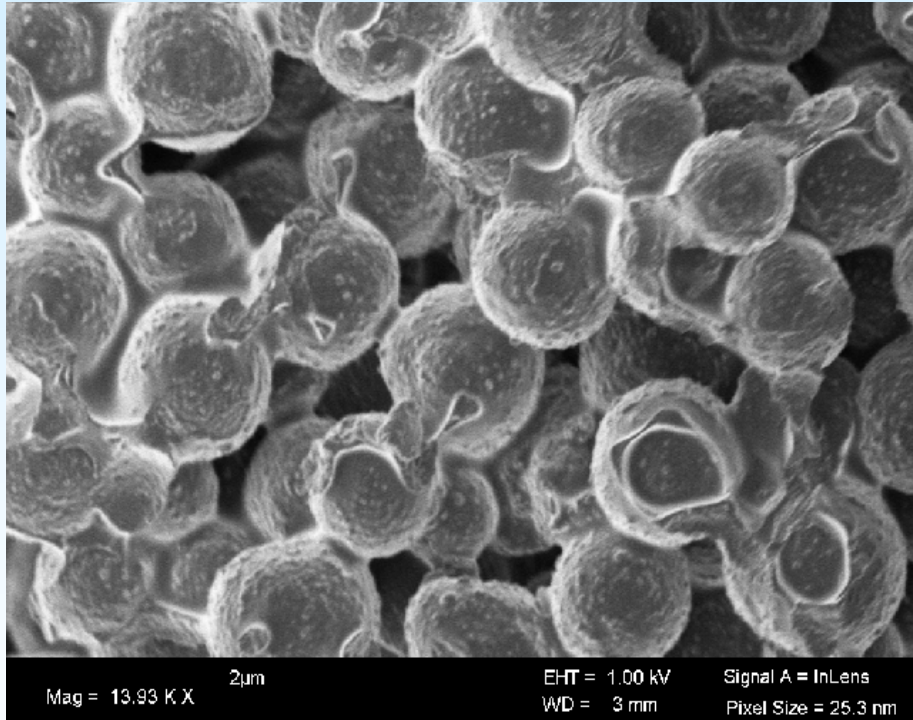


The hydrolysis products of the Sol-gel precursor undergo polycondensation reactions

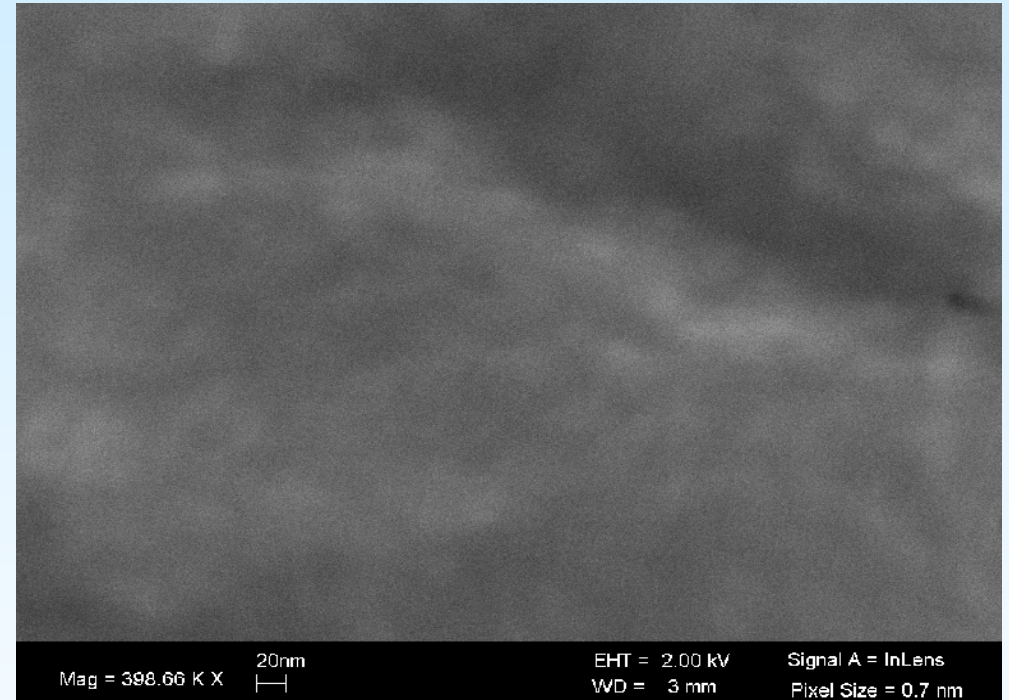
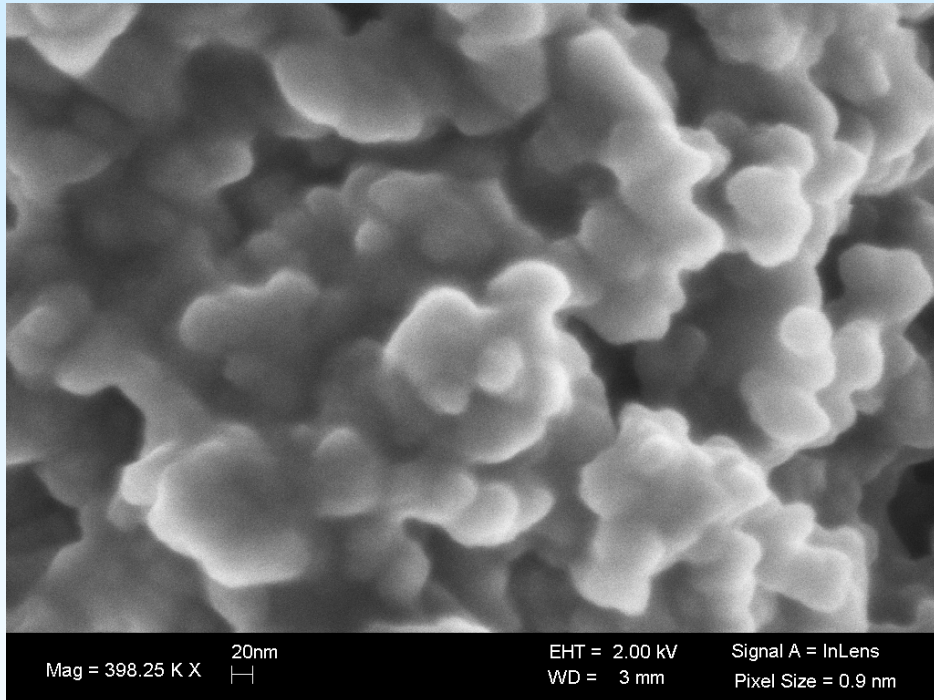


3-D polymeric sol-gel network chemically bonded to the silanol moieties on the the PDMS surface

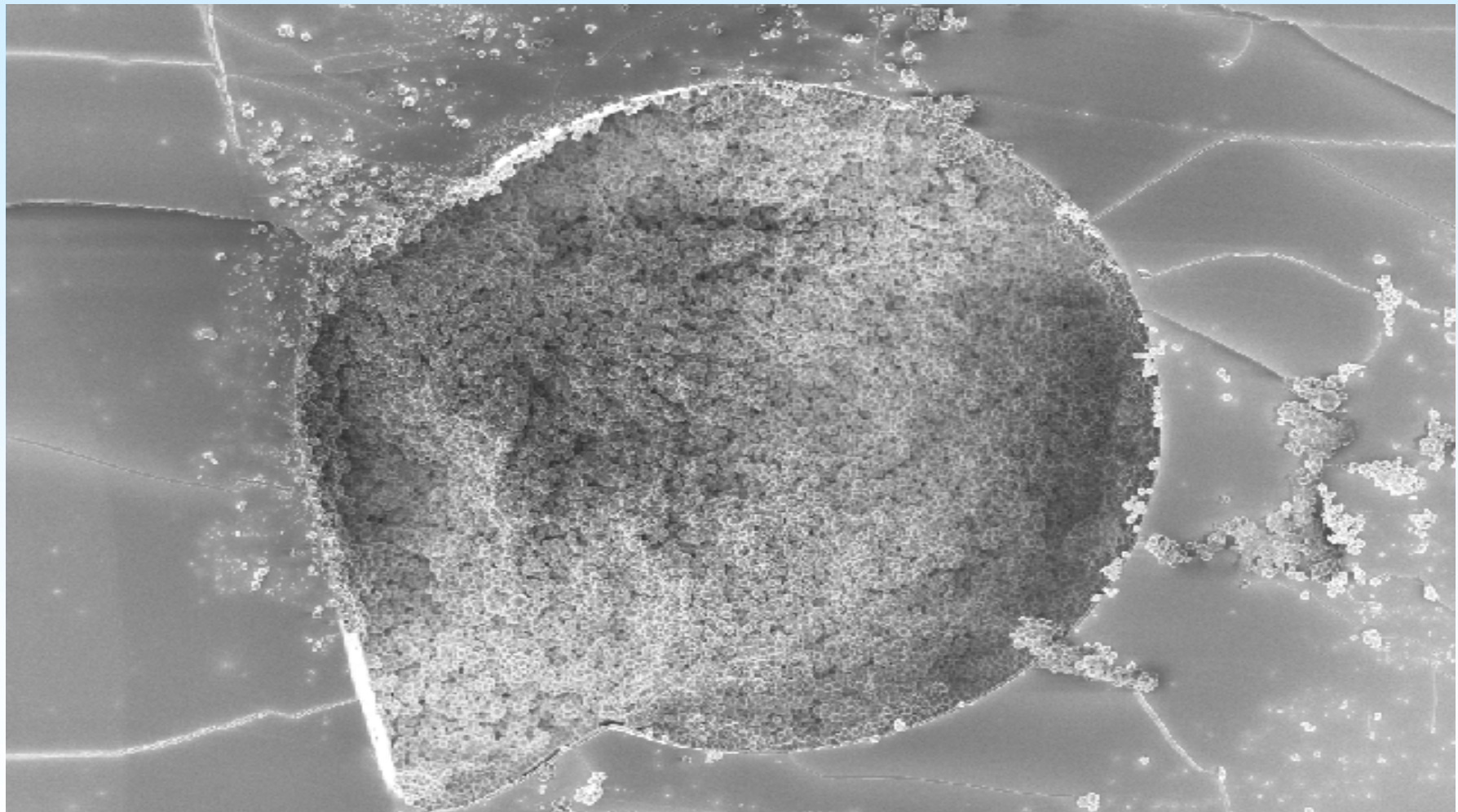
SEM Image of the Sol-Gel Entrapped Silica Particles



Sol-gel Immobilized Silica Nano Particles



SEM of the Cross Section of the Silica Packed Channel at 541X Magnification.



Mag = 541 X

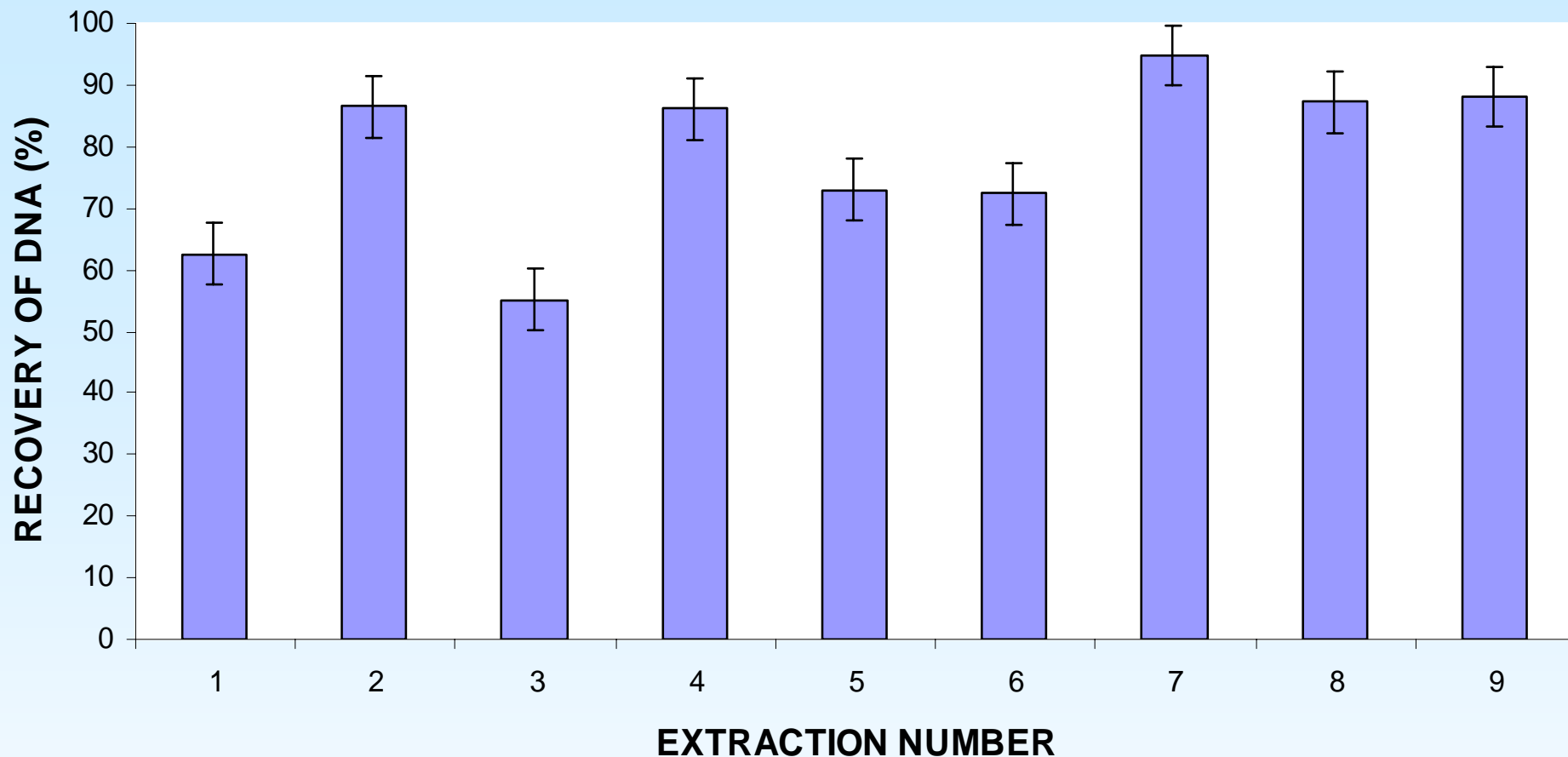
30 μ m

EHT = 1.00 kV

WD = 3 mm

Signal A = InLens

Pixel Size = 651.1 nm



Percentage Recovery of DNA extractions from E.coli crude lysates using SPE chips filled with sol-gel immobilized nano silica particles (14nms). Average DNA Recovery is $78 \pm 13\%$ ($X \pm RSD$).

[Extraction conditions: 10 μ l of load, 5 μ l of wash (80% IPA) and 60 μ l of elution buffer (0.1M Tris HCL, pH 7.5) were used at a flow rate of 10 μ l/min. Crude lysate load solution contained about 10ng/ μ l DNA. DNA quantification was done by fluorescence imaging of Sybr green stained DNA at 488nm excitation and emission settings at 520nm BP 40, 600V, normal sensitivity using TyphoonTM 9410 Variable Mode Imager (Amersham Biosciences, Uppsala, Sweden)].

Summary and Final Thoughts

- **Nanoparticles offer:**
 1. **Large surface area.**
 2. **Unique sorption characteristics**
- **Fabrication requires self assembly techniques.**
- **The process can be fine-tuned to specifications by functionalization of nanoparticles – particularly carbon nanotubes.**

Acknowledgements

Financial support:

- **US-EPA Star Program: Grant Number: RD830901.**
- **New Jersey Commission on Science and Technology through the Center for Microflow Control.**